Large Extra-Dimension Searches, LoI

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Motivation

From the model point of view:

- Extra space-time dimensions were originally introduced to "alleviate" the so called hierarchy problem, i.e. the large difference between the electroweak and the GUT (or even the Planck) energy scales.
- Models with large extradimensions can also accommodate non-zero neutrino masses, specifically, of the Dirac type which are naturally small.

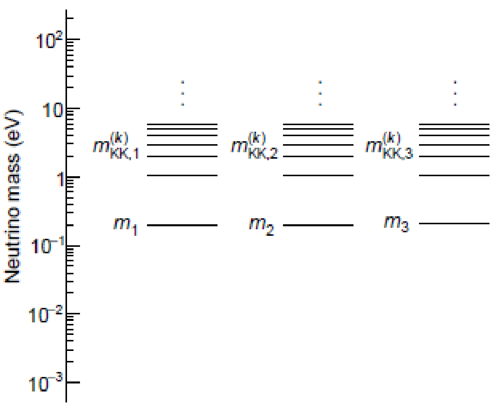
From the phenomenological point of view:

- The LED model (Davoudiasl et. al 2002) turns out to be pretty testable at neutrino oscillation experiments (Machado et. al 2011).
- MINOS (2016) experiment set a constrain to the LED compactification radius to R<0.45μm at 90% of C.L. when the lightest neutrino mass $m_0 \to 0$.

Main consequences

LED model (Davoudiasl et. al 2002) :

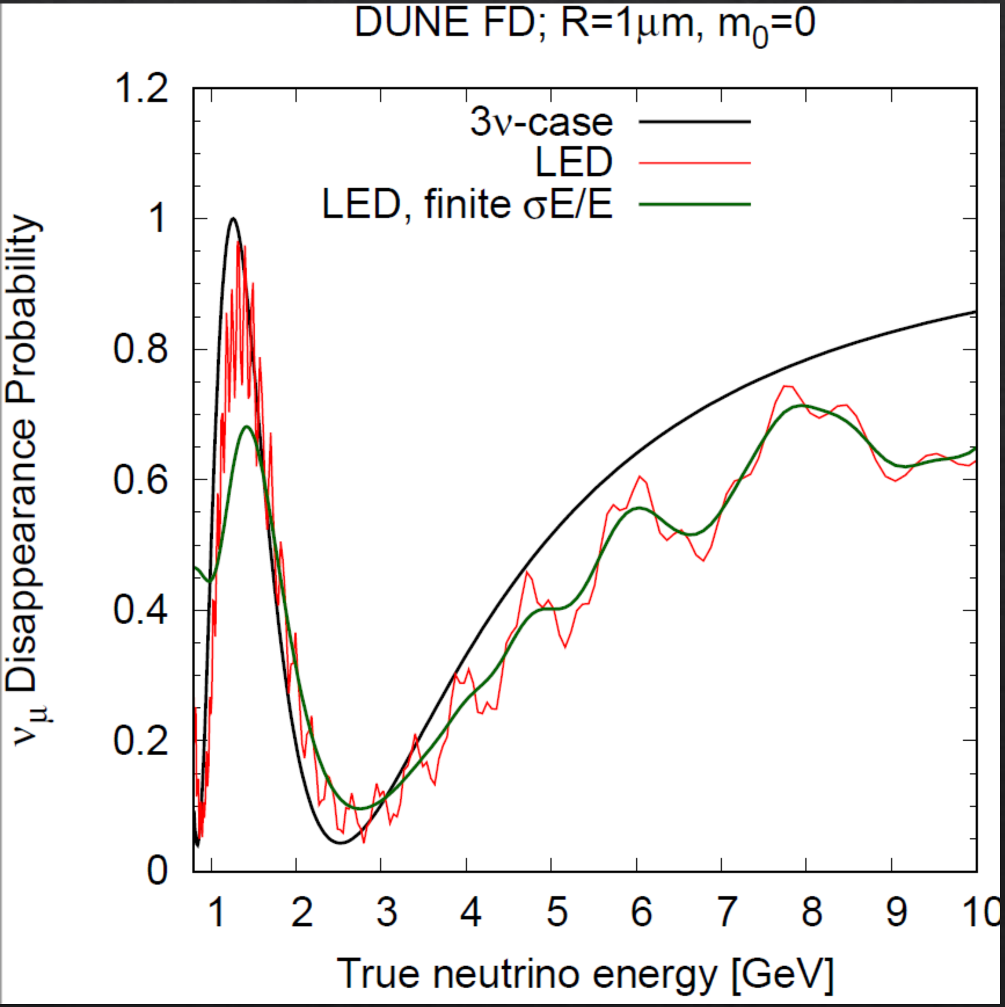
- In this model, three bulk right-handed neutrinos coupled (via Yukawas's) to the three active brane neutrinos.
- After compactification of the effective extra dimension, from the four dimensional (brane) point of view, the right-handed neutrino appears as an infinite tower of sterile neutrinos or Kaluza-Klein modes.



Phenomenological consequences:

- The sterile-active mixings and the new oscillation frequencies modify the active 3ν-oscillations therefore distorting the neutrino event energy spectrum.
- Departures from the standard oscillations due to the existence of LED can then be probed at neutrino oscillation experiments (Long & Short baselines).

Main Features

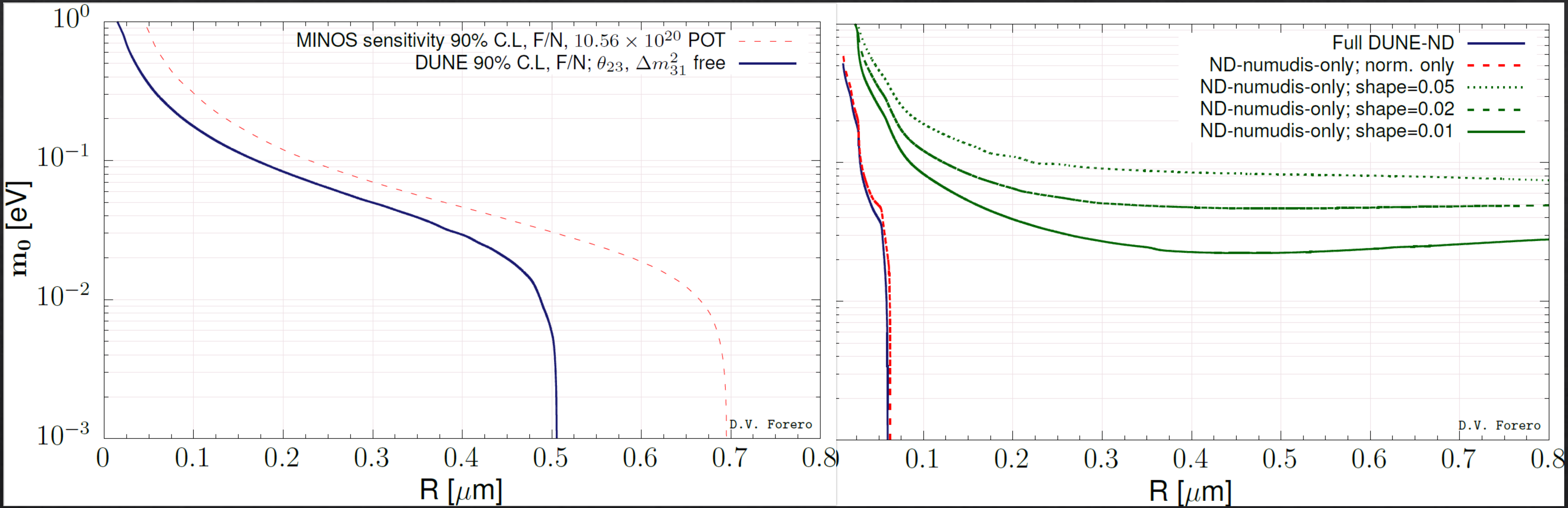


Most active (sterile) case corresponds to n=0 (n>>1). The standard 3ν-neutrino oscillations are recovered in the limit $R \rightarrow 0$.

- Global reduction of survival probabilities, which is typically noticeable at high energies (Machado et. al 2011).
- Appearance of modulations and fast oscillations to Kaluza-Klein states.

- These shape-like features can be exploited at the analysis level. This have been done in MINOS (2016).
- Sensitivity analyses for several osc. Exps (Machado et. al 2011), IceCube (Esmaili et. al. 2014), DUNE (Berryman et. al 2016… “revamped” for DUNE FD TDR & ND CDR), and SBN (Stenico 2018).

DUNE as a case study



Potential improvement arises from the DUNE capabilities to reconstruct the main LED modulations at high energies

Summary

- The LED model (Davoudiasl et. al 2002) turns out to be pretty testable at neutrino oscillation experiments.
- Neutrino oscillations within this LED model provide unique features that can be explored in parallel to the search for a sterile neutrino oscillation at the eV energy scale in the economical ‘3+1’ scenario.
- Long-baseline experiments detecting neutrinos at high energies, and with a percent-level energy resolution, are good candidates for LED probes.
- In particular, combining information from near and far detectors allows to probe lighter and heavier KK modes simultaneously. Therefore, a two-detector analysis with realistic systematics is very promising for future LED searches.
- Neutrino oscillation experiments provide a competitive, model independent constrain to R, which is complementary to other searches, for instance in neutrinoless double beta decay experiments, in core collapse supernovae, at colliders like the LHC, and in kinematical tests (Basto et. al 2012).

Thanks for your attention

I take this opportunity to thank all the contributing authors that participate in the LoI, thank you all!